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METHODS OF CROSSING LARGE RIVERS WITH PIPELINES

INTRODUCTION

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Over the past few decades the conveyance of oil and natural gas over long distances by pipeline has become common. In crossing large rivers, pipelines were usually laid directly on the river bed or in shallow trenches, but this proved to be somewhat unsafe. Many pipelines have failed due to scour of the river bed or due to high drag forces on the pipeline. Recent concern for the environment has resulted in many new and innovative methods for crossing rivers, all varying widely in terms of safety and economics.

BY

DR. V.J. GALAY

AND

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NORTHWEST HYDRAULIC CONSULTANTS LTD.

PREPARED FOR:

FIRST ANNUAL

ALBERTA HYDROTECHNICAL SEMINAR

EDMONTON, ALBERTA

February 2, 1976

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RIVER CROSSING METHODS

A variety of river crossing methods for pipelines are shown in the attached table. The table shows a conceptual sketch of the crossing method along with comments related to construction, design and safety.

This presentation deals with the various crossing methods by treating case histories. The case histories are itemized below:

1. Pipeline on River Bed

   Mississippi River at Fitler Bend.

   A total of 26 pipelines were placed at this location, with only 6 still functional after 25 years.

2. Pipeline in Shallow Trench

   Similkameen River in British Columbia.

   The natural gas pipeline failed when the river changed course and exposed the pipeline.

3. Pipeline in Shallow Trench with Riprap Cover

   Fraser River in Vancouver.

   Natural gas pipeline was designed with riprap cover to minimize exposure due to scour and the movement of large sandwaves.

4. Deep Trench - Dredging or Dragline

   Trans-Alaska Pipeline.

   Various river crossings designed to have pipeline below lowest possible scour level.

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5. Deep Trench - Slurry Trench

Cutoffs below earth dams.

6. Deep Trench - Fluidization

Menai Strait Crossing (United Kingdom).

Fluidization device developed by Shell used to bury pipe with a minimum of 10 feet of cover.

7. Directional Drilling

San Joaquin River, California.

A hole is drilled under a river using a Dyna-Drill and a pipeline is subsequently pushed through the hole.

8. Bridge on Piles

Sutlej River in Pakistan.

A pressurized triangular truss bridge was constructed on top of concrete piles. The truss members served as the pipeline for conveyance of natural gas.

9. Pontoon Bridge

Pontoon bridge for traffic in Italy.

Pontoon bridges are often used for water crossings and can be used to support a pipeline.

10. Gas Wells and Underground Storage

This concept of underground storage is common to the oil industry. The use of the concept to cross rivers is new, but should be feasible if geological conditions are favourable.

11. Tunnel

The placing of a pipeline in a tunnel is only economical if the tunnel serves other purposes.

12. Suspension Bridge

Tanana River, Alaska.

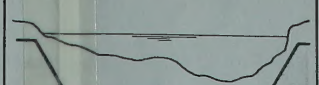
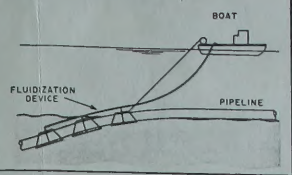
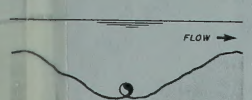
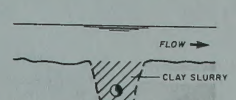
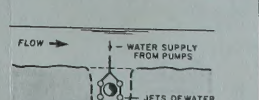
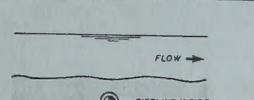
The Trans Alaska Pipeline will cross the Tanana River on a suspension bridge. The site is at a confluence with the Delta River where the hydraulics of a deep burial would have been complicated.

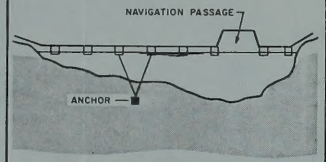
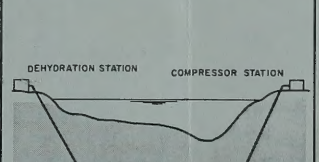
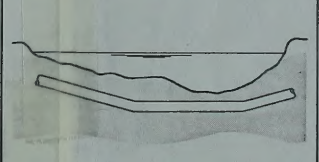
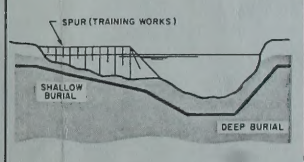
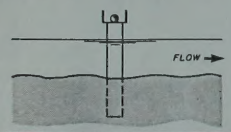
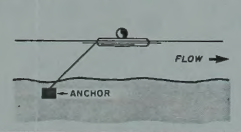
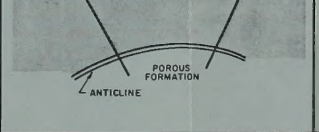
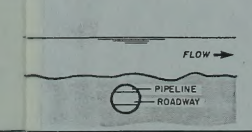
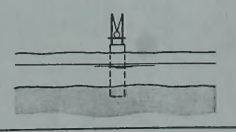
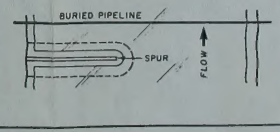
13. Combined Shallow and Deep Burial

Deitrich River, Alaska.

The construction of spurs and dikes across braided rivers will minimize the length of deep burial and may be economical.

METHODS OF CROSSING LARGE RIVERS WITH PIPELINES

CROSSING METHOD / DETAILS	PIPELINE ON RIVER BED	SHALLOW TRENCH	SHALLOW TRENCH WITH RIPRAP COVER	DEEP TRENCH: DREDGING	DEEP TRENCH: SLURRY TRENCH	DEEP TRENCH: FLUIDIZATION	DIRECTIONAL DRILLING
RIVER CROSS-SECTION							
RIVER PROFILE							
CONSTRUCTION COMMENTS	1. PIPELINE MAY BE LAID FROM BARGE OR PULLED ACROSS RIVER.	1. TRENCH EXCAVATED BY DREDGE OR DRAGLINE. 2. PIPELINE MAY BE LAID FROM BARGE OR PULLED ACROSS RIVER. 3. TRENCH BACKFILLED BY RIVER'S BEDLOAD SEDIMENT TRANSPORT.	1. TRENCH EXCAVATED BY DREDGE OR DRAGLINE. 2. PIPELINE MAY BE LAID FROM BARGE OR PULLED ACROSS RIVER. 3. RIPRAP PLACED FROM BARGE.	1. SEVERAL DREDGES MAY BE NECESSARY TO EXCAVATE LARGE VOLUMES OF MATERIAL IN A SHORT TIME. 2. DREDGING POSSIBLE ONLY DURING LOW WATER. 3. TRENCHING ON RIVER BANK MAY BE DIFFICULT.	1. TRENCH EXCAVATED BY DRAGLINE. 2. EXCAVATION MUST BE COMPLETED IN ONE LOW SEASON AS END OF PIPELINE DIFFICULT TO RECOVER. 3. COFFER DAMS AND ACCESS ROADS MUST BE CONSTRUCTED.	1. PIPELINE LAID ON BED, THEN FLUIDIZATION DEVICE PASSES OVER PIPELINE AND CAUSES PIPELINE TO SINK INTO FLUIDIZED SAND. 2. SEVERAL PASSES OF DEVICE MAY BE NECESSARY TO ACHIEVE DEEP BURIAL.	1. INITIAL HOLE DRILLED BY DYNA-DRILL WHICH IS AN IN-HOLE DRILLING MOTOR POWERED BY WATER, MUD OR AIR. PIPE THEN PUSHED INTO PILOT HOLE.
NOTES	1. PIPELINES GENERALLY LAID IN SINUSOIDAL PATTERN WITH SEVERAL SMALLER PIPELINES AT ONE CROSSING TO MINIMIZE FAILURE. 2. PROBABILITY OF PIPELINE FAILURE DUE TO MOVEMENT OF BED AND DRAG FORCES IS HIGH.	1. PROBABILITY OF PIPELINE FAILURE DUE TO MOVEMENT OF BED AND DRAG FORCES IS HIGH.	1. DESIGN OF RIPRAP COVER MAY NECESSITATE HYDRAULIC MODEL STUDIES.	1. DEPTH OF BURIAL IS TO BE BELOW LOWEST POSSIBLE SCOUR LEVEL OF THE RIVER. 2. PIPELINE SHOULD NOT FAIL DUE TO SCOUR.	1. CONTINUOUS CIRCULATION OF SLURRY DIFFICULT IF TRENCH IS LONG. 2. DEPTH OF BURIAL IS TO BE BELOW LOWEST POSSIBLE SCOUR LEVEL OF THE RIVER.	1. MAXIMUM BURIAL DEPTH HAS BEEN 20 FT. 2. POWERFUL BOAT AND PUMPS REQUIRED TO PULL FLUIDIZATION DEVICE AND TO FLUIDIZE SAND. 3. DEVICE DOES NOT WORK IN COHESIVE SOILS; ONLY FOR SAND BEDS.	1. PILOT HOLES UP TO 1000 FEET LONG HAVE BEEN DRILLED; LENGTH DEPENDS UPON THE SIZE OF THE THRUST MACHINE. 2. SHIFTING OF THE RIVER SHOULD NOT AFFECT PIPELINE AS POINT OF ENTRY AND EXIST USUALLY FAR AWAY FROM RIVER.

CROSSING METHOD / DETAILS	BRIDGE ON PILES	PONTOON BRIDGE	GAS WELLS AND UNDERGROUND STORAGE	TUNNEL	SUSPENSION BRIDGE	COMBINED SHALLOW AND DEEP BURIAL (TRAINING WORKS)
RIVER CROSS-SECTION						
RIVER PROFILE						
CONSTRUCTION COMMENTS	1. PILES CONSTRUCTED BY CONCRETE OR STEEL DEPENDING ON DEPTH. 2. ASSEMBLY OF TRUSSES NOT DIFFICULT.	1. ASSEMBLY OF PONTOONS (OR FLOATS) CAN BE COMPLETED QUICKLY. 2. EXTENSIVE MAINTENANCE NECESSARY TO ENSURE PIPELINE IS NOT SEVERELY DAMAGED.	1. PIPES DRILLED INTO POROUS GEOLOGICAL FORMATION BY CONVENTIONAL DRILLING TECHNIQUES.	1. CONVENTIONAL TUNNEL CONSTRUCTION TECHNIQUES APPLY: TUNNEL CANNOT BE EXCESSIVELY DEEP UNDER RIVER DUE TO HIGH HYDRO-STATIC HEAD.	1. CAISSON CONSTRUCTED FOR TOWERS AND SOLID LAND ANCHORS NECESSARY. 2. CONSTRUCTION CAN BE CARRIED OUT THROUGHOUT YEAR - NO LOW FLOW LIMITATIONS.	1. DEEP BURIAL BY DREDGING OR DRAGLINE. 2. RIVER TRAINING WORKS WILL USUALLY REQUIRE RIPRAP PROTECTION.
NOTES	1. SIMPLE TRUSSES SHOULD BE ADEQUATE TO SUPPORT PIPELINE. 2. TRUSS MEMBERS MAY BE PRESSURIZED PIPES AND COULD CONVEY NATURAL GAS. 3. PILES MUST BE DESIGNED TO WITHSTAND DRAG FORCES, WATER WAVE FORCES, WIND FORCES AND SANDWAVE LOADINGS.	1. PONTOONS MAY CONSIST OF BOATS, FLOATS, OR WATERPROOF TANKS (SIMILAR TO FLOATING DREDGE LINES). 2. DESIGN OF PROPER ANCHORS MAY REQUIRE MORE RESEARCH AND HYDRAULIC MODEL TESTING. 3. NAVIGATION OPENING USUALLY NECESSARY ALONG PIPELINE. 4. FLEXIBLE HIGH PRESSURE COUPLING NECESSARY AT BANK TO ALLOW FOR CHANGE IN WATER LEVEL.	1. METHOD GENERALLY APPLICABLE TO GAS TRANSMISSION. 2. EXTENSIVE GEOLOGICAL STUDIES NECESSARY PRIOR TO ASSESSING FEASIBILITY OF THIS METHOD.	1. THIS METHOD ONLY ECONOMICAL IF TUNNEL IS CONSTRUCTED FOR OTHER PURPOSES (TRANSPORT). 2. THIS METHOD IS USUALLY THE MOST EXPENSIVE.	1. THIS METHOD IS COMMON IN CANYONS OR RIVERS HAVING NON-ERODING BANKS. 2. THIS METHOD IS USUALLY EXPENSIVE.	1. THIS METHOD USUALLY APPLICABLE TO BRAIDED, WIDE RIVERS WHERE DEEP BURIAL BECOMES EXPENSIVE. 2. DEEP BURIAL PORTION MUST BE BELOW LOWEST POSSIBLE SCOUR LEVEL.

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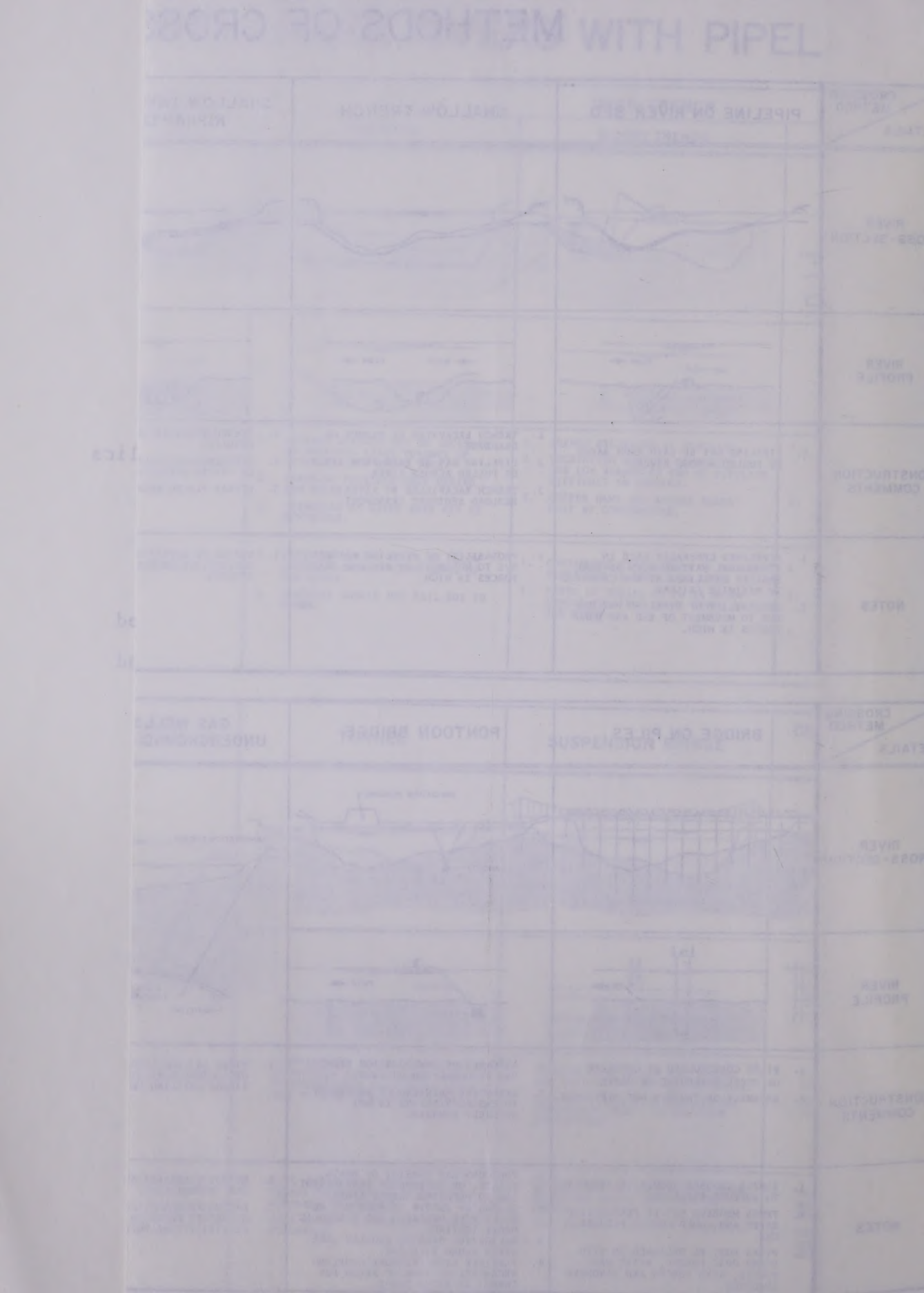

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